Air Quality and Meteorology

OVERVIEW

Air Quality

- Emissions
- Chemistry
- Characterization

Meteorology

- Basic weather patterns
- Temperature (surface/aloft)
- Winds (surface/aloft)
- Transport
- Clouds
- Review of key features

Air Quality – Types

Primary - emitted directly from source

Secondary - formed in atmosphere from reaction of primary pollutants

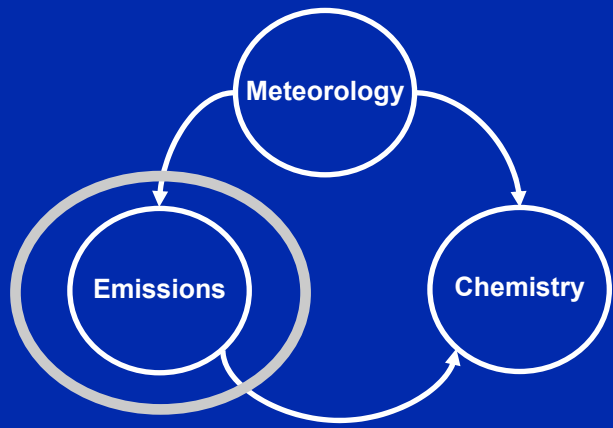
Precursors - primary pollutants that form secondary pollutants

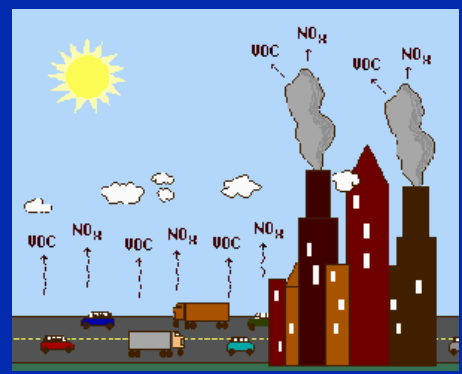
Air Quality – Major Pollutants

Pollutant	Abbreviation	Type
Carbon Monoxide	CO	Primary
Sulfur Dioxide	SO_2	Primary
Ozone	O_3	Secondary
Nitrogen Dioxide	NO_2	Secondary
Hydrocarbon Compounds	HC	Primary & Secondary
Particulate Matter	PM	Primary & Secondary

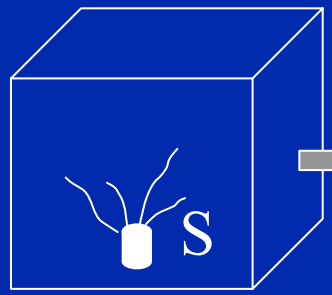
Air Quality – Emissions

- Man-made sources
  - NO_x through combustion
  - VOCs through combustion and numerous other sources
  - SO_2 through combustion of coal and oil that contains sulfur
- Natural sources (biogenic)
  - VOCs from trees/vegetation
  - NOx from soils (Midwest fertilizer)
- Concentration depends on
  - Source location, density, and strength
  - Meteorology



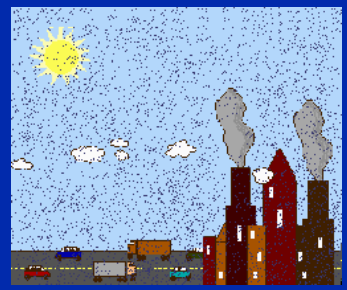


Air Quality – Emissions



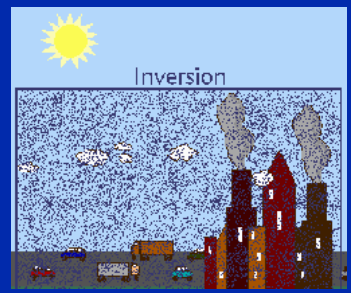
Wind speed (WS)

Concentration ∝ S/WS



Vertical mixing (VM)

Concentration ∝ S/VM



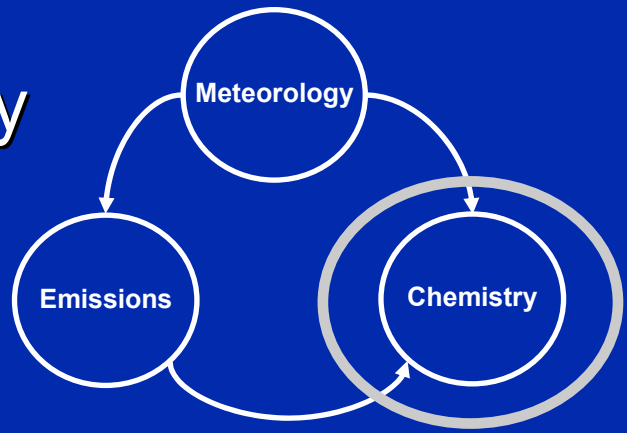
Courtesy of New Jersey
Department of Environmental Protection

- Key processes
  - Source location, density, and strength
  - Dispersion (horizontal mixing) - wind speed
  - Vertical mixing - inversion

Air Quality – Chemistry

Simplified view of ozone chemistry

- $NO_2 + O_2 + Sunlight \rightarrow O_3$ Production
- NO + O3 → NO2 + O2 Destruction



- NO + VOC + Sunlight → NO2 + VOC' Production of NO2

Key processes

- Ample sunlight (UV)
- High concentrations of precursors (VOC, NO, NO_2)
  - –Dispersion
  - –Vertical mixing
- Temperature

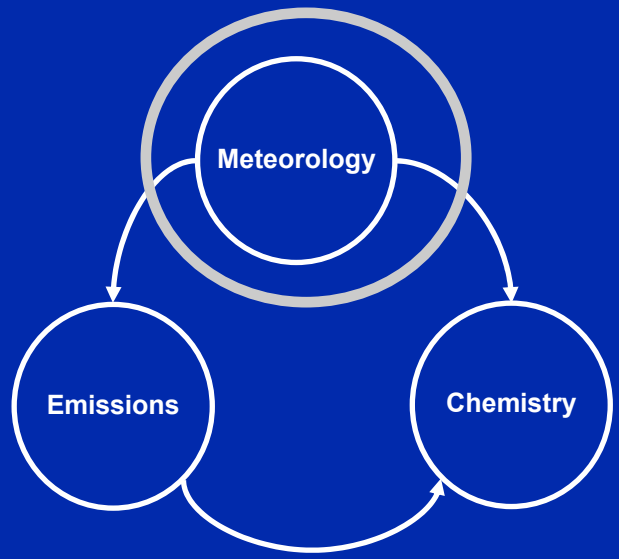
Air Quality – Meteorology Key Processes

Meteorology key processes

- Dispersion (horizontal mixing)
- Vertical mixing
- Sunlight
- Transport

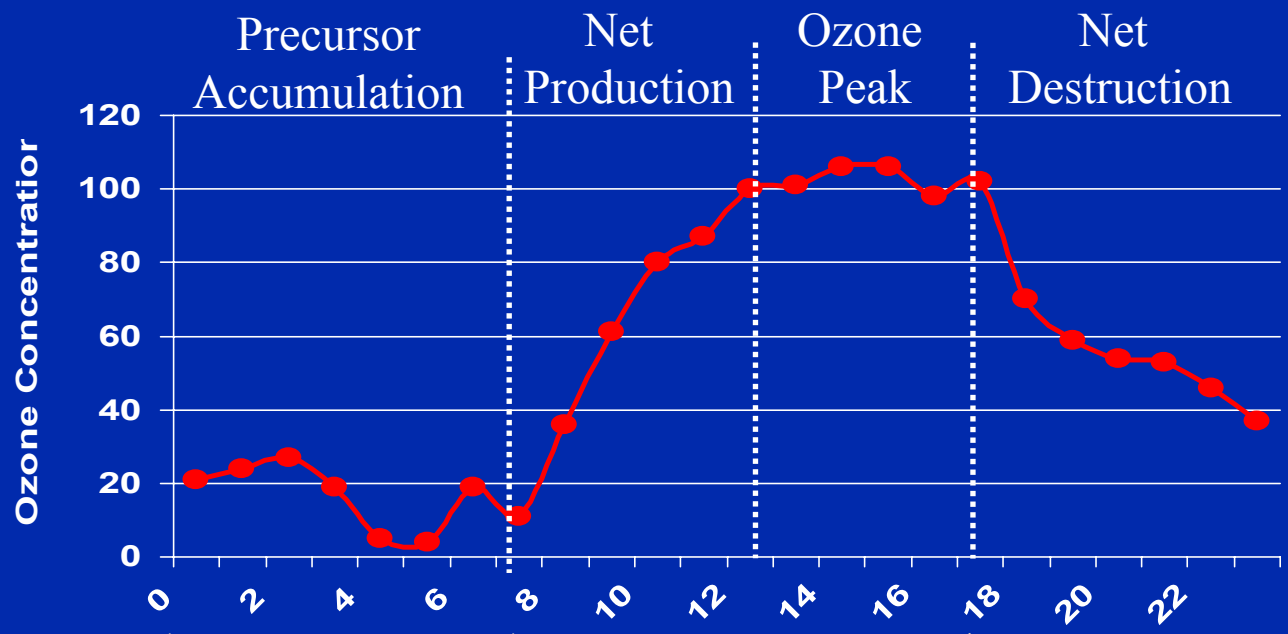
Variations by

- Weather pattern
- Geography
- Diurnal
- Season



Air Quality – Urban Site

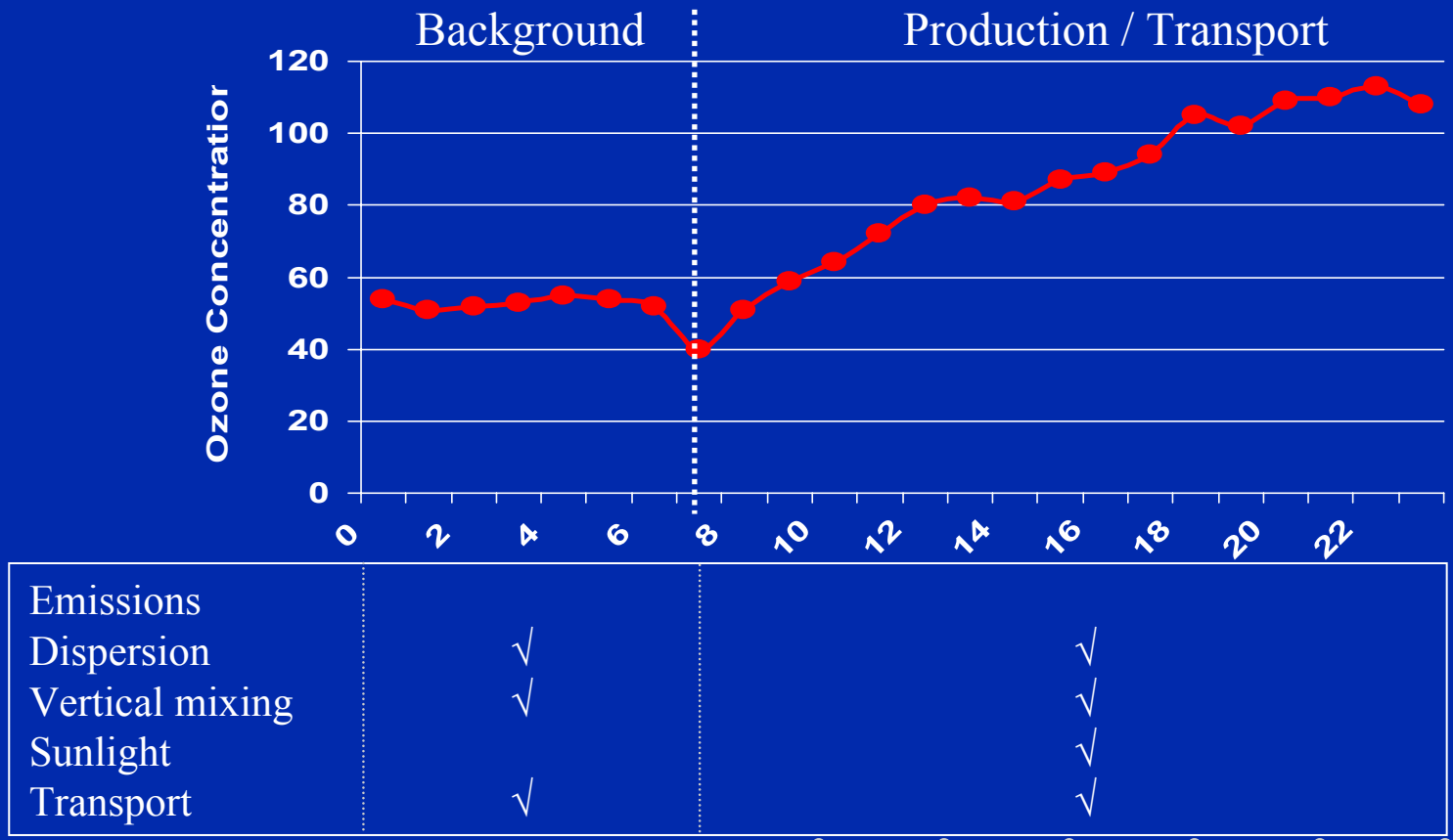
Hourly ozone concentrations on July 23, 2001, at an urban site in Nashville, Tennessee



Emissions	√	√		√
Dispersion	√	√		√
Vertical mixing	√	√	√	√
Sunlight		√	√	
Transport			√	√

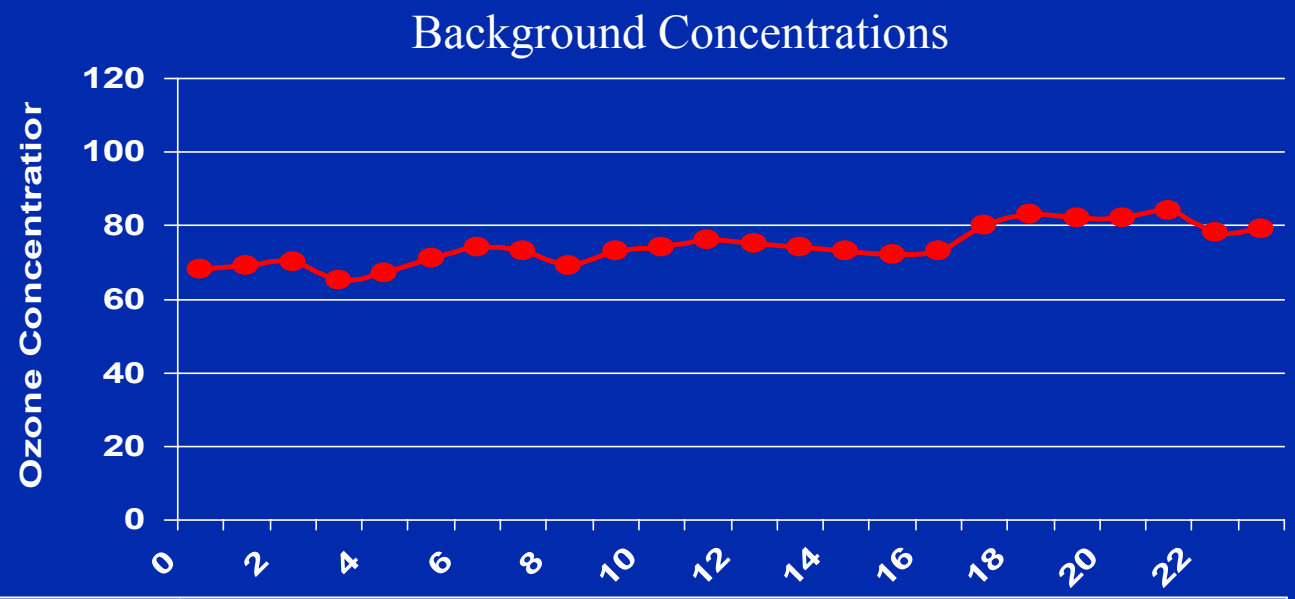
Air Quality – Rural and Downwind

Hourly ozone concentrations on May 22, 2001, at rural downwind site in Grass Valley (Sacramento), California



Air Quality – High Altitude

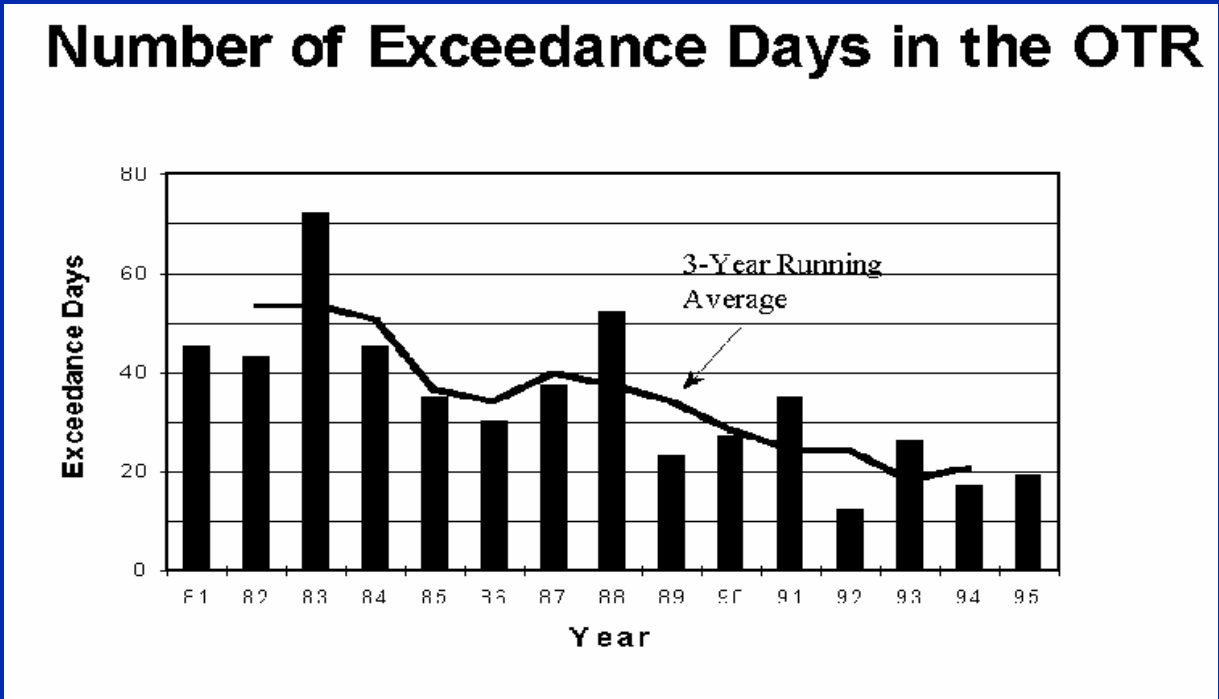
Hourly ozone concentrations on May 23, 2001, at a high-altitude site at Fry Pan, North Carolina



Emissions	
Dispersion	
Vertical mixing	√
Sunlight	
Transport	√

Air Quality – Characterization

- Examine long-term trends for changes in
  - number of high days
  - location of peaks

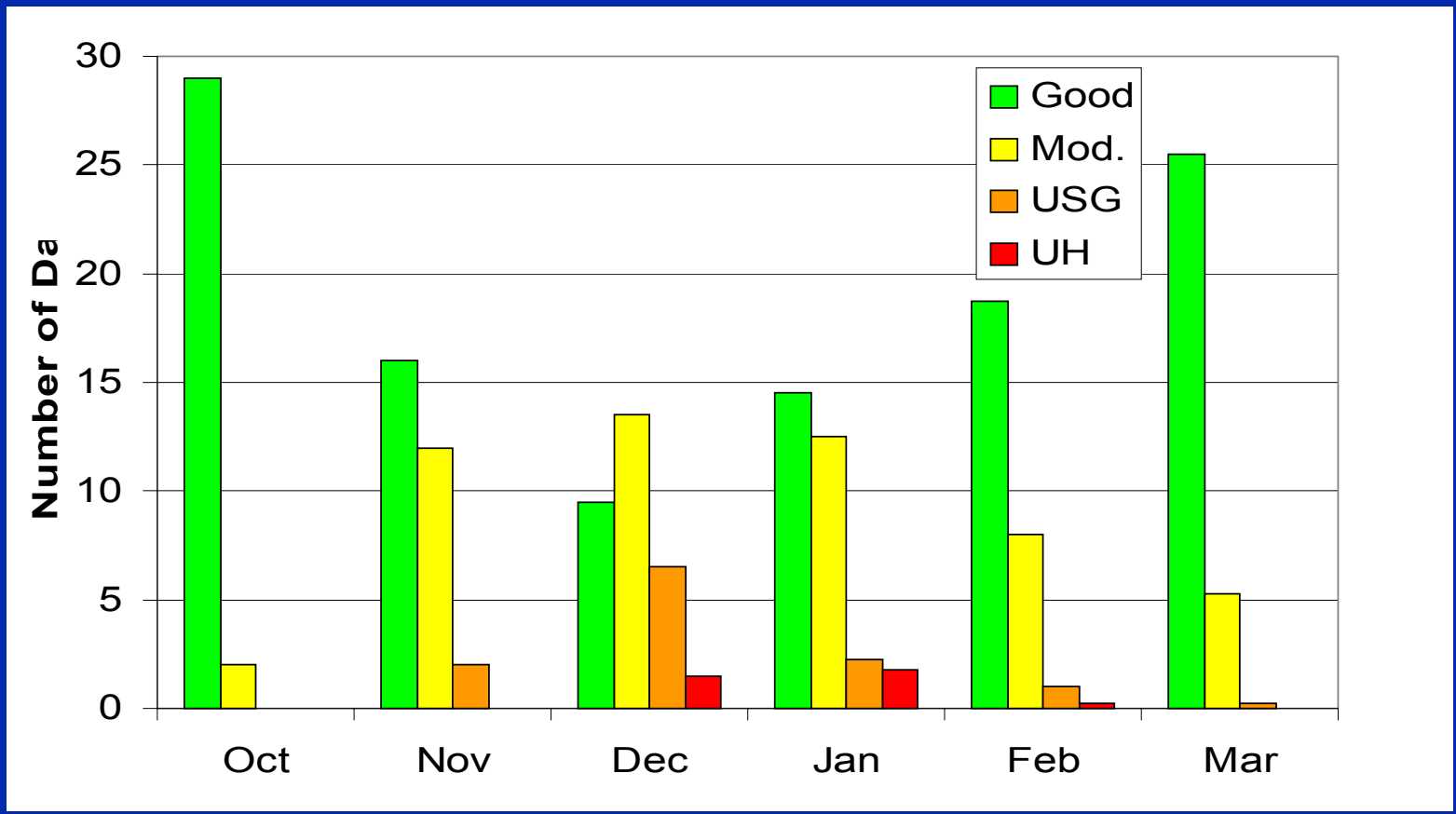


Number of ozone exceedance days and the three-year running average between 1981-1995 in the Northeast ozone transport region (Chinkin et al., 1995a).

Air Quality – Characterization

- Examine seasonal trends

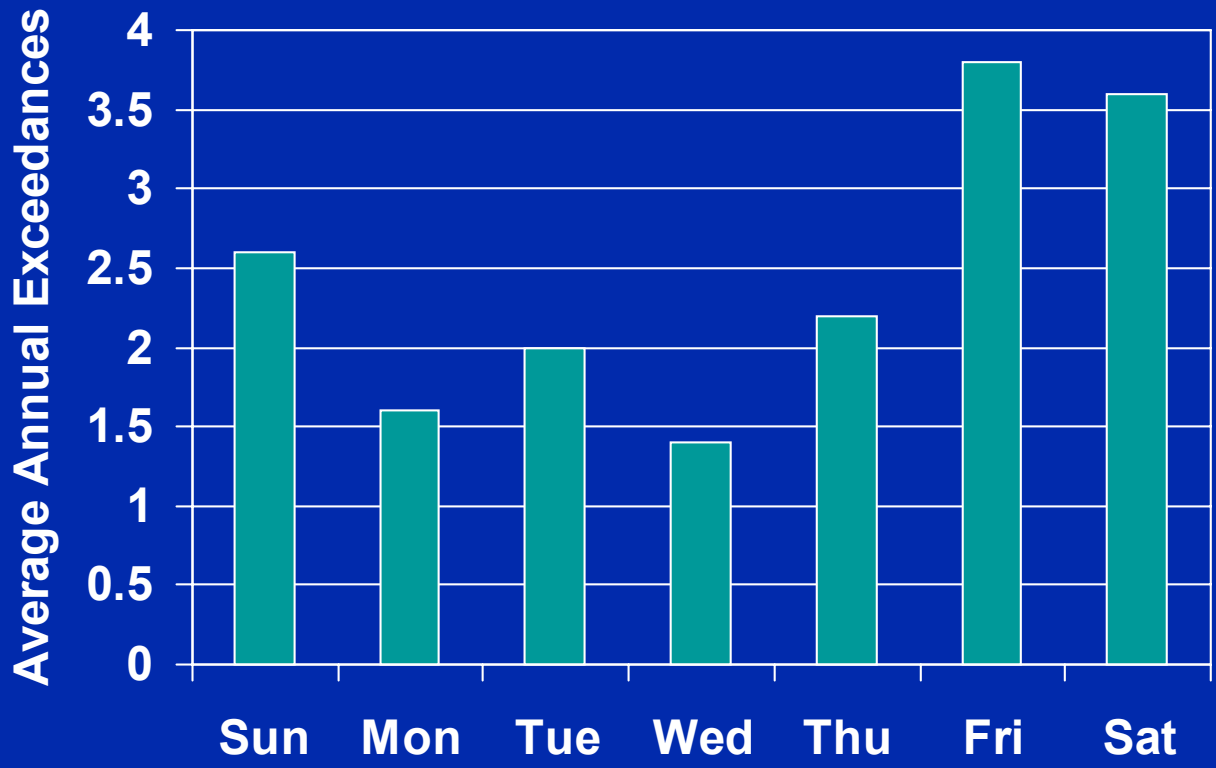
Average AQI days for $PM_{2.5}$ in Salt Lake City, Utah (1999-2001)



Air Quality – Characterization

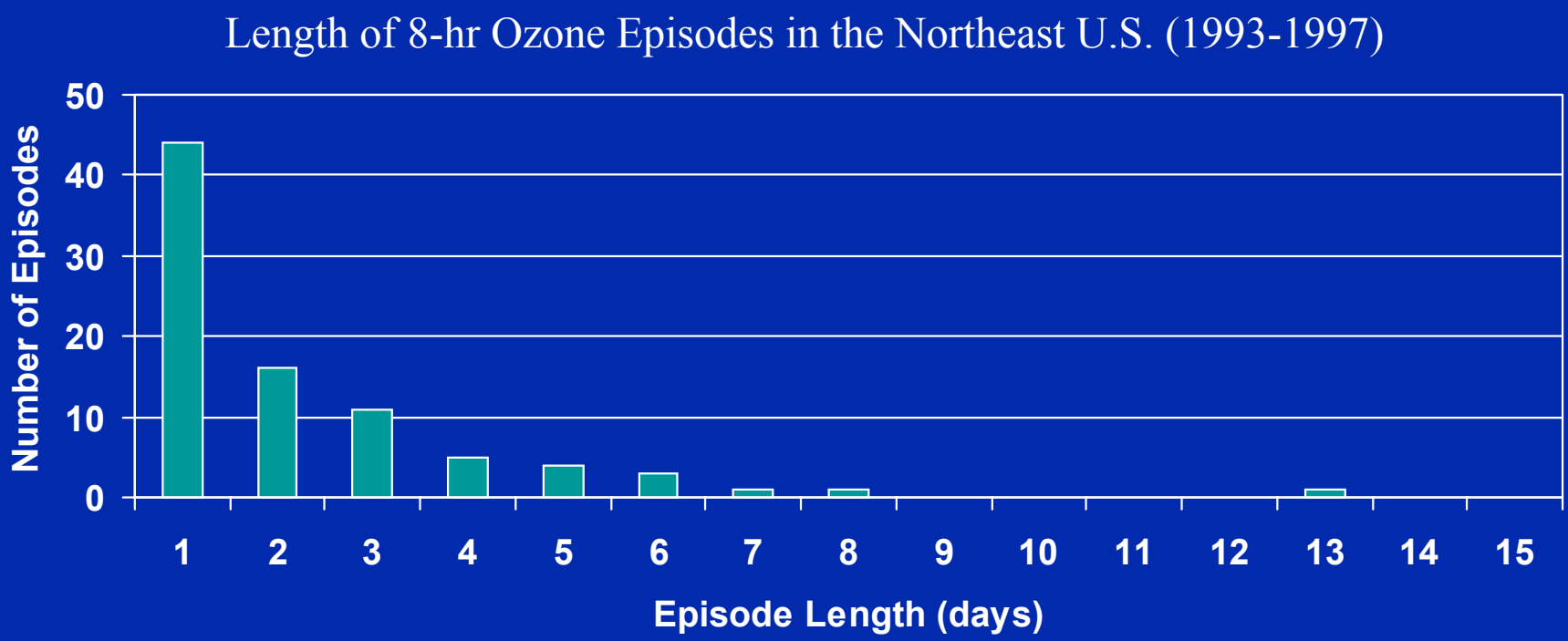
- Examine day-of-week relationships

8-hr ozone exceedances by day of week in Columbus, Ohio (1996-2000)



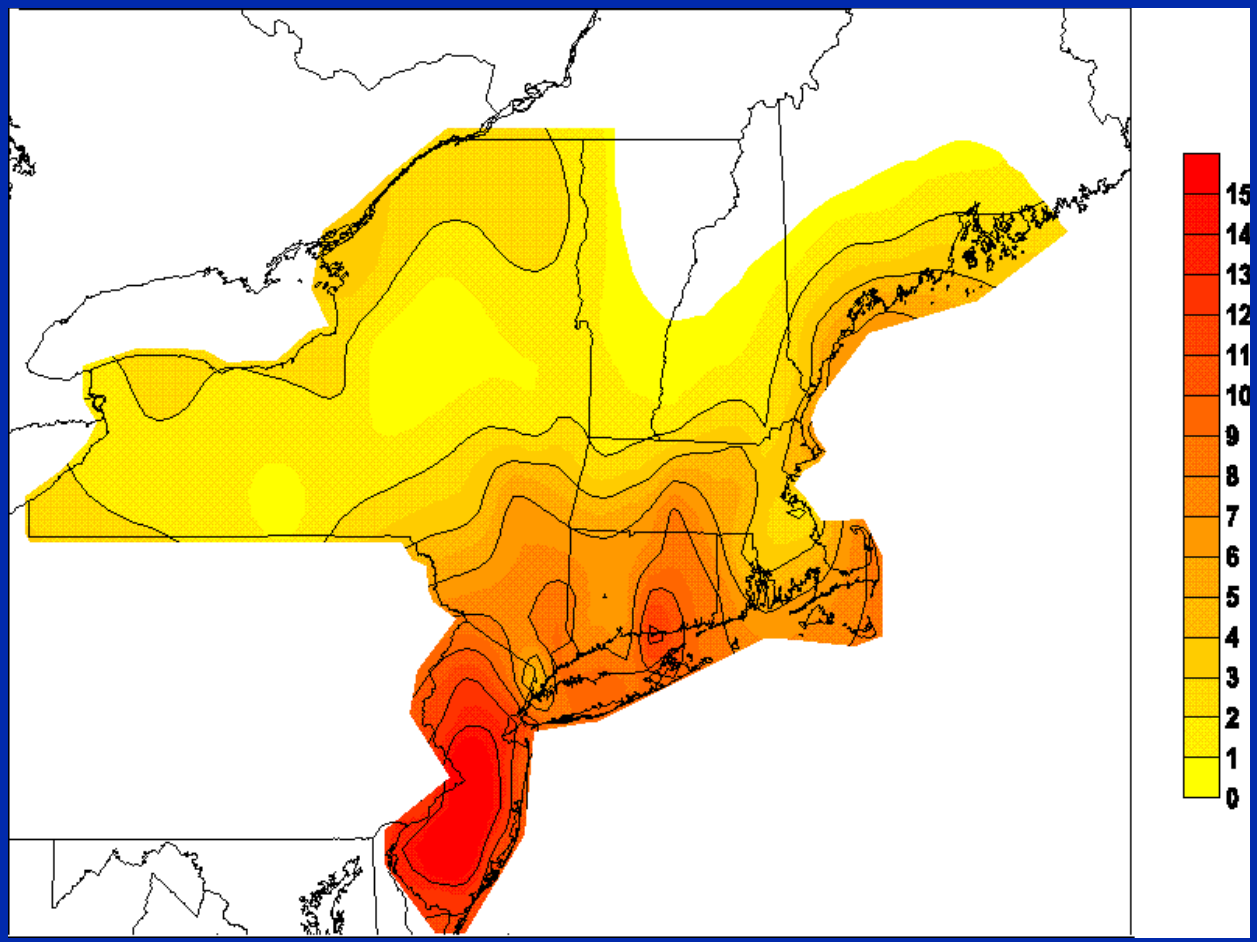
Air Quality – Characterization

- Examine length of episodes



Length of 8-hr episodes that occurred in the Northeast U.S. during 1993 to 1997. Most episodes are one-day long; however, most exceedance days occur within episodes that are two days or longer. Seventy-eight percent of 8-hr exceedance days occur in 8-hr episodes that are two days or longer.

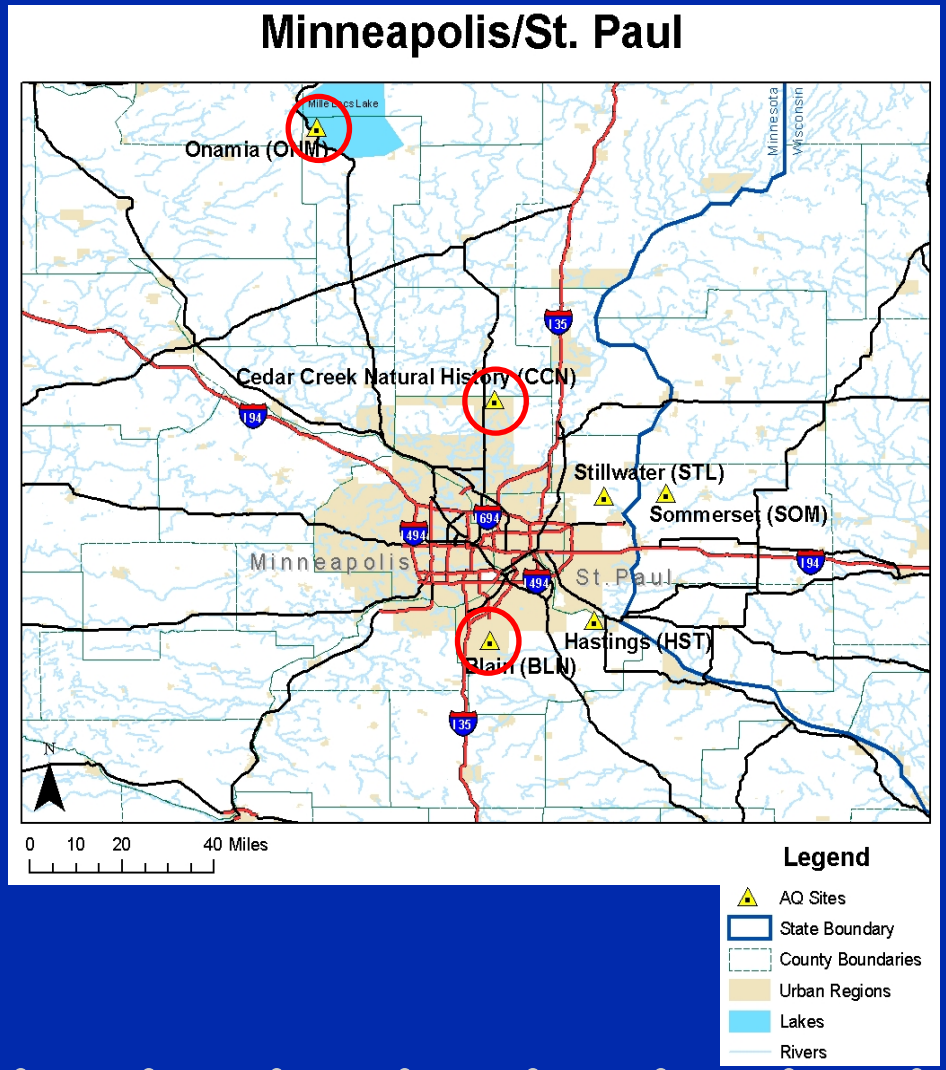
Air Quality – Characterization



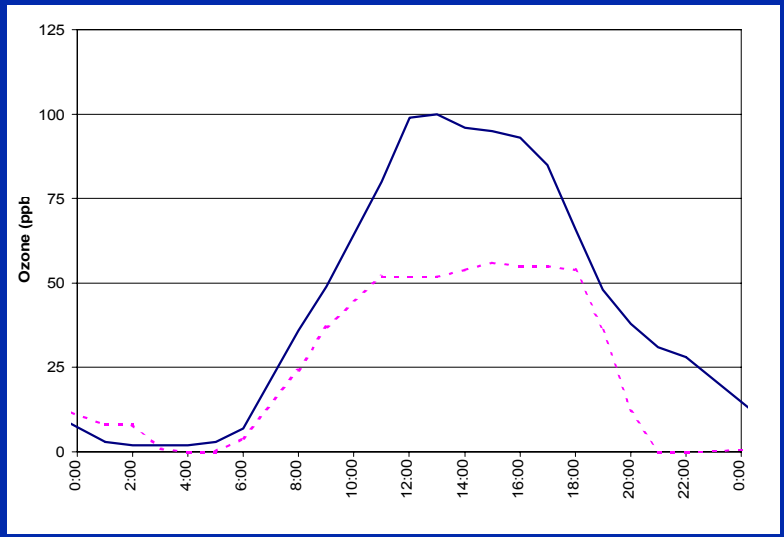
Contour plot of the average number of 8-hr site exceedances per year from 1993 to 1997. The contour lines are drawn for every two days (Dye et al., 1998).

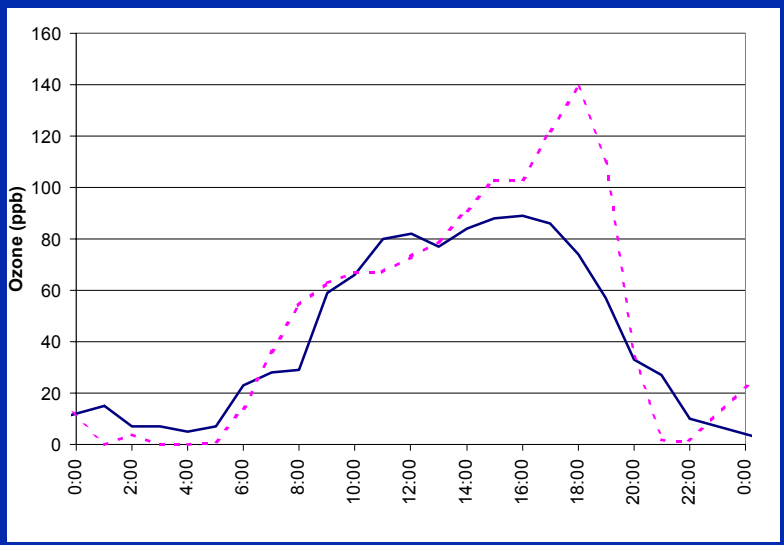
Air Quality – Characterization

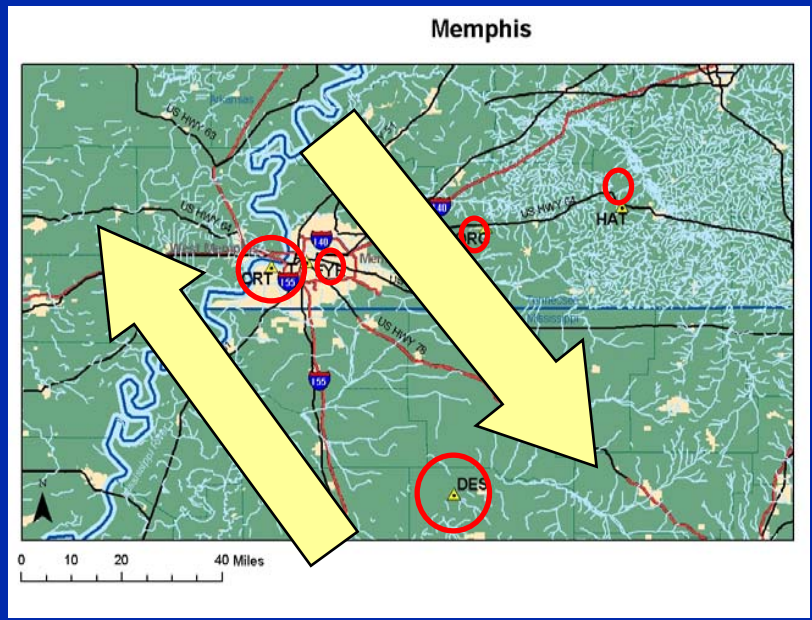
- Evaluating monitoring sites
  - Representativeness
    - street
    - neighborhood
    - urban
    - background
    - downwind
  - Local terrain
  - Proximity to emissions



Air Quality – Characterization







○ Monitoring Sites

Summary

Forecasting air quality requires an understanding of the processes that produce pollution:

Emissions
Sunlight
Dispersion
Vertical mixing
Transport

- Next Steps
  - Review of Meteorological Processes
- Questions